

9-13-00

EI 964 281 515 US

Docket No. 95-18A2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re: Application of:

Thelma G. Manning,
Joseph L. Prezelski,
Sam Moy,
Bernard Strauss,
James Hartwell,
Arpad A. Juhasz,
And
Robert J. Lieb

Examiner: Unknown at Present

Serial No.: Herewith

Group Art Unit: Unknown at Present

Filed: Herewith

For: High Energy Thermoplastic Elastomer

**CONTINUATION APPLICATION
TRANSMITTAL FORM**

Honorable Commissioner of
Patents & Trademarks
Washington, D.C. 20231

Sir:

This is a request for filing a continuation application, pursuant to 37 C.F.R. § 1.63.

1. Enclosed is a copy of the latest inventor-signed prior application, including the declarations as originally filed. I hereby verify that I believe the attached papers are a true copy of the latest inventor-signed prior application, serial number 09/351,530, as originally filed on July 12, 1999, by the above-named inventors, for HIGH ENERGY THERMOPLASTIC ELASTOMER. And, further, that all statements made herein of my own knowledge are true and all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements, and the like, so made, are punishable by fines or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of this application or any patent issuing thereon.

2. A separate Fee Letter is enclosed, which authorizes the Commissioner to charge the filing fee for this application to the U.S. Army Deposit Account No. 19-2201.



3. Please amend the enclosed specification by inserting before the first line thereof the sentence: --This application is a continuation of application serial number 09/351,530, as originally filed on July 12, 1999, for High Energy Thermoplastic Elastomer.-- . A preliminary amendment is also enclosed herewith.

4. The prior application is assigned of record to: The Government of the United States, as represented by the Secretary of the Army.

5. The power of attorney in the prior application is to: John F. Moran, Reg. No. 26,313. The power appears in the original papers in the prior application. An Appointment of Associate Attorney to the undersigned is enclosed herewith.

6. Address all future communications to:

U.S. Army TACOM-ARDEC
Attn: AMSTA-AR-GCL
R. Beam / Building 3
Picatinny Arsenal, NJ 07821-5000

(Telephone No.: (973) 724-3411)

7. Address of signator, Robert Charles Beam, Reg. No. 28,182:

U.S. Army TACOM-ARDEC
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Sept. 11, 2000
Date

Respectfully submitted,



Robert Charles Beam
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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FEE LETTER

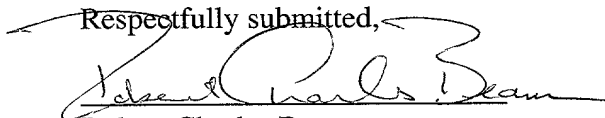
Honorable Commissioner of
Patents & Trademarks
Washington, D.C. 20231

Sir:

The United States Patent and Trademark Office is hereby authorized to charge the sum of \$710. for the filing fee in the above-captioned application, from the U.S. Army's account, Deposit Account No.: 19-2201.

The United States Patent and Trademark Office is also authorized to charge any further fee amount or credit any overpayment to the same account. A duplicate copy of this authorization is enclosed.

Sept. 11, 2000
Date

Respectfully submitted,

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EI 964 281 515 US

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For: HIGH ENERGY THERMOPLASTIC
ELASTOMER PROPELLANT

PRELIMINARY AMENDMENT

Honorable Commissioner of Patents and Trademarks,
Washington, D.C. 20231

Dear Sir:

Please cancel Claims 1 to 5.

Please add the following new claims:

6. An extruded propellant material comprising:

a first propellant composition comprising:

an energetic oxetane thermoplastic elastomeric binder comprising from about five percent to about thirty percent by weight, based on the total weight of said first propellant, and chosen from the group consisting of 3,3-bis-azidomethyl-oxetane (BAMO), 3-azidomethyl-3-methyloxetane (AMMO), and combinations thereof, and

a high energy explosive filler comprising from about seventy percent to about ninety-five percent by weight, based on the weight of said first propellant, and chosen from the group consisting of hexanitrohexaazaisowurtzitane (CL-20), 1,3,3-trinitroazetidine (TNAZ), cyclotrimethylene trinitramine (RDX), and combinations thereof,

said first propellant composition having an impetus of at least about thirteen hundred joules per gram (1300 J/g) and a first and relatively slow burn rate measured at 25 kpsi;

a second propellant composition comprising

an energetic oxetane thermoplastic elastomeric binder comprising from about five percent to about thirty percent by weight, based on the total weight of said second propellant, and chosen from the group consisting of 3,3-bis-azidomethyl-oxetane (BAMO), 3-azidomethyl-3-methyloxetane (AMMO), and combinations thereof, and

a high energy explosive filler comprising from about seventy percent to about ninety-five percent by weight, based on the weight of said second propellant, and chosen from the group consisting of hexanitrohexaazaisowurtzitane (CL-20), 1,3,3-trinitroazetidine (TNAZ), cyclotrimethylene trinitramine (RDX), and combinations thereof,

said second propellant composition having an impetus of at least about thirteen hundred joules per gram (1300 J/g) and a second and relatively fast burn rate on the order of at least about three times faster than said first burn rate of said first propellant composition, as measured at 25 kpsi.

7. The propellant composition of claim 6, further comprising an explosive plasticizer comprising from about four percent to about seven percent by weight, based on the weight of said propellant composition, and chosen from the group consisting of 1,3,3-trinitroazetidine (TNAZ), butane-trio-trinitrate (BTTN), trimethylolethane trinitrate (TMETN), triethylene glycol dinitrate (TEGDN), bis,2,2-dinitropropylacetyl/bis2,2-dinitropropylformal (BDNPA/F), methylnitrateethylnitramine (methyl NENA), ethylnitrateethylnitramine (ethyl NENA), and combinations thereof.

8. The propellant composition of claim 6, wherein said second burn rate of said second propellant composition is at least about twenty-one inches per second (21.0 in./sec.) as measured at 25 kpsi.

9. The propellant composition of claim 6, wherein said first burn rate of said first propellant composition is below about five inches per second (5.0 in./sec.) as measured at 25 kpsi.

10. The propellant composition of claim 9, wherein said first burn rate of said first propellant composition is in the range of from about four and four-tenths inches per second (4.4 in./sec.) to about four and five-tenths inches per second (4.5 in./sec.) as measured at 25 kpsi.

11. The propellant composition of claim 6, wherein said second or faster burn rate of said second propellant composition is between about three and five times faster than said first or slower burn rate of said second propellant composition, as measured at 25 kpsi.

12. The propellant composition of claim 11, wherein said second or faster burn rate of said second propellant composition is about four and eight-tenths times faster than said first or slower burn rate of said second propellant composition, as measured at 25 kpsi.

13. A process for the preparation of a propellant composition material, comprising the steps of:

a. preparing a first propellant composition by:

heating an energetic oxetane thermoplastic elastomeric binder comprising from about five percent to about thirty percent by weight, based on the total weight of said first propellant, and chosen from the group consisting of 3,3-bis-azidomethyl-oxetane (BAMO), 3-azidomethyl-3-methyloxetane (AMMO), and combinations thereof, to a temperature of about ninety-five degrees Celsius (95° Celsius) or until said elastomeric binder melts, and

mixing into said elastomeric binder a high energy explosive filler comprising from about seventy percent to about ninety-five percent by weight, based on the weight of said first propellant, and chosen from the group consisting of hexanitrohexaazaisowurtzitane (CL-20), 1,3,3-trinitroazetidine (TNAZ), cyclotrimethylene trinitramine (RDX), and combinations thereof,

to form a first propellant composition having an impetus of at least about thirteen hundred joules per gram (1300 J/g) and a relatively slow burn rate measured at 25 kpsi;

cooling said first propellant composition to a temperature of from about fifty-five degrees Celsius (55° Celsius) to about ninety-one degrees Celsius (91° Celsius) to solidify said first propellant composition;

b. preparing a second propellant composition by:

heating an energetic oxetane thermoplastic elastomeric binder comprising from about five percent to about thirty percent by weight, based on the total weight of said second propellant, and chosen from the group consisting of 3,3-bis-azidomethyl-oxetane (BAMO), 3-azidomethyl-3-methyloxetane (AMMO), and combinations thereof, to a temperature of about ninety-five degrees Celsius (95° Celsius) or until said elastomeric binder melts, and

mixing into said elastomeric binder a high energy explosive filler comprising from about seventy percent to about ninety-five percent by weight, based on the weight of said second propellant, and chosen from the group consisting of hexanitrohexaazaisowurtzitane (CL-20), 1,3,3-trinitroazetidine (TNAZ), cyclotrimethylene trinitramine (RDX), and combinations thereof,

to form a second propellant composition having an impetus of at least about thirteen hundred joules per gram (1300 J/g) and a second and relatively fast burn rate on the order

of about three times faster than said first burn rate of said first propellant composition as measured at 25 kpsi;

cooling said second propellant composition to a temperature of from about fifty-five degrees Celsius (55° Celsius) to about ninety-one degrees Celsius (91° Celsius) to solidify said second propellant composition;

c. mixing said first propellant composition and said second propellant composition, and extruding the mixture in a desired form.

14. An extruded propellant material prepared by the method of:

a. preparing a first propellant composition by:

heating an energetic oxetane thermoplastic elastomeric binder comprising from about five percent to about thirty percent by weight, based on the total weight of said first propellant, and chosen from the group consisting of 3,3-bis-azidomethyl-oxetane (BAMO), 3-azidomethyl-3-methyloxetane (AMMO), and combinations thereof, to a temperature of about ninety-five degrees Celsius (95° Celsius) or until said elastomeric binder melts, and

mixing into said elastomeric binder a high energy explosive filler comprising from about seventy percent to about ninety-five percent by weight, based on the weight of said first propellant, and chosen from the group consisting of hexanitrohexaazaisowurtzitane (CL-20), 1,3,3-trinitroazetidine (TNAZ), cyclotrimethylene trinitramine (RDX), and combinations thereof,

to form a first propellant composition having an impetus of at least about thirteen hundred joules per gram (1300 J/g) and a first and relatively slow burn rate measured at 25 kpsi;

cooling said first propellant composition to a temperature of from about fifty-five degrees Celsius (55° Celsius) to about ninety-one degrees Celsius (91° Celsius) to solidify said first propellant composition;

b. preparing a second propellant composition by:

heating an energetic oxetane thermoplastic elastomeric binder comprising from about five percent to about thirty percent by weight, based on the total weight of said second propellant, and chosen from the group consisting of 3,3-bis-azidomethyl-oxetane (BAMO), 3-azidomethyl-3-methyloxetane (AMMO), and combinations thereof, to a temperature of about ninety-five degrees Celsius (95° Celsius) or until said elastomeric binder melts, and

mixing into said elastomeric binder a high energy explosive filler comprising from about seventy percent to about ninety-five percent by weight, based on the weight

of said second propellant, and chosen from the group consisting of hexanitrohexaazaisowurtzitane (CL-20), 1,3,3-trinitroazetidine (TNAZ), cyclotrimethylene trinitramine (RDX), and combinations thereof,

to form a second propellant composition having an impetus of at least about thirteen hundred joules per gram (1300 J/g) and a second and relatively fast burn rate on the order of about three times faster than said first burn rate of said first propellant composition, as measured at 25 kpsi;

cooling said second propellant composition to a temperature of from about fifty-five degrees Celsius (55° Celsius) to about ninety-one degrees Celsius (91° Celsius) to solidify said second propellant composition;

c. mixing said first propellant composition and said second propellant composition, and extruding the mixture in a desired form.

15. The propellant composition of claim 14, further comprising an explosive plasticizer comprising from about four percent to about seven percent by weight, based on the weight of said propellant composition, and chosen from the group consisting of 1,3,3-trinitroazetidine (TNAZ), butane-trio-trinitrate (BTTN), trimethylolethane trinitrate (TMETN), triethylene glycol dinitrate (TEGDN), bis,2,2-dinitropropylacetyl/bis2,2-dinitropropylformal (BDNPA/F), methylnitrateethylnitramine (methyl NENA), ethylnitrateethylnitramine (ethyl NENA), and combinations thereof.

REMARKS

The claims are 6 to 15. Former claims 1 to 5 have been cancelled in favor of newly presented claims 6 to 15 in order to point out with greater particularity and claim more distinctly the subject matter which the applicants regard as their invention. It is submitted that the subject matter of the cancelled claims has been carried forward and that no new matter has been introduced. It is further submitted that the newly presented claims have been drafted directly from the Specification and Claims of the present Application as filed, and all limitations of the newly-presented claims may be found therein.

In the parent application, the claims were rejected under 35 U.S.C. § 103 (a) as being unpatentable over United States Patent 5,210,153 to Manser and Miller in view of United States Patent 5,587,553 to Braithwaite, Lund, and Wardle, United States Patent 5,529,649 to Lund, Highsmith, Braithwaite, and Wardle, and United States Patents 5,690,868 and 5,716,557 to Strauss, Manning, Prezelski and Moy. It is the Examiner's position that the Manser and Miller reference teaches the basic invention, and that it would be obvious to substitute similar fillers as taught by the other references cited.

With respect to this rejection under 35 U.S.C. § 103 (a), it is submitted that the art assembled by the Examiner in the parent application does not show the invention defined in the present claims.

The primary reference, United States Patent 5,210,153 to Manser and Miller is entitled Thermoplastic elastomers having alternative crystalline structure for use as high energy binders. This reference shows a number of such elastomers including those employed in the present invention. But unlike the present invention, the Manser and Miller reference teaches the polymerization of a specific structure from these monomers with block polymers having a crystalline structure, or "A" type, surround a block polymer having an amorphous structure, or "B" type, to form an ABA triblock polymer.

Such polymers are not employed in the present invention and it is not seen how such teaching has relevance. At most, the reference shows that monomers such as 3,3-bis(azidomethyl)oxetane (BAMA) and 3-azidomethyl-3-methyloxetane (AMMO) have application in high energy binders. The reference does not describe a two propellant formulation having different burn rates using such ABA block polymers, and does not suggest that such complex triblock polymers could be employed in such an application.

Four secondary references are cited. United States Patent 5,587,553 to Braithwaite, Lund and Wardle is entitled High performance pressable explosive compositions. This reference shows pressable compositions of a liquid polymer with an oxidizer. Poly(bis(azidomethyl)oxetane) (poly-BAMO) and poly(bis(difluoroaminomethyl)oxetane) (poly-AMMO) are two of the disclosed polymers, but the monomeric forms of these materials are not employed, as they are in the present invention. Several of the filler materials of the present invention are shown, but these materials are well known to the art and no claim is made to these materials in the present invention outside the two propellant compositions defined in the claims. The reference does not disclose and does not suggest a two propellant composition where each propellant has a different burn rate. Certainly, nothing in the combination of the primary Manser and Miller reference and the secondary Braithwaite, Lund and Wardle reference shows a two propellant system with different burn rates and the requirement that one burn rate be three time faster than the other.

United States Patent 5,529,649 is entitled Insensitive High Performance Explosive Compositions. This reference shows the use of 4,10-dinitro-2,6,8,12-tetraoxa-4,10-diazatetra-cyclo[5.5.0.0^{5,9}.0^{3,11}]-dodecane in explosive applications. Polymeric and copolymeric forms of the binders of the present invention are suggested in combination with the disclosed explosive, a "cage" compound, as are many of the fillers. But nothing in the reference, or in the combination of this secondary reference with the primary reference to Manser and Miller, shows a two propellant system with different burn rates and the requirement that one burn rate be three times faster than the other.

United States Patent 5,716,557 is entitled Method of Making High Energy Explosives and Propellants. This reference shows a method for forming high energy explosives by permitting an explosive filler to dissolve or plastisize in a molten high

energy binder. This is the basic technology employed in preparing each of the first and second propellant compositions of the present invention. But nothing in the reference, or in the combination of this reference with the primary reference to Manser and Miller, shows a two propellant system with different burn rates and the requirement that one burn rate be three times faster than the other.

United States Patent 5,690,868 is entitled Multi-Layer High Energy Propellants. This reference is probably the closest reference in the prior art, and shows a multi-layer propellant composition comprising two separately formulated propellants having high energy and different burn rates. But the compositions are separately formulated and remain separate, in separate layers, and the burn rate of one only needs to be twice the rate of the other. Nothing in the reference, or in the combination of this reference with the primary reference to Manser and Miller, shows a two propellant mixture with different burn rates and the requirement that one burn rate be three times faster than the other.

It is submitted, therefore, that none of the references that were cited in the parent application, either alone or in combination, anticipate the claims of the present invention or render them obvious. It is further submitted that the claims in their present form patentably distinguish over the cited art.

WHEREFORE, examination and early allowance are respectfully requested.

Respectfully,

Sept. 11, 2000



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HIGH ENERGY THERMOPLASTIC ELASTOMER PROPELLANT

The invention described herein may be manufactured,
used, and licensed by or for the U.S. Government for U.S.
5 Governmental purposes.

FIELD OF THE INVENTION

The present invention relates generally to a high energy
10 propellant composition. More particularly the invention relates to a
propellant that includes an energetic thermoplastic elastomer as a
binder and a high energy, high density filler.

15

20

BACKGROUND OF THE INVENTION

As with the evolution of many technologies, new weapon systems require higher munitions performance. Current standard propellants
5 do not have adequate energy to deliver the performance required for systems that are presently being developed. JA2, which is a standard double base propellant used, for example, in the M829A1 and M829A2 tanks rounds, has an impetus value of 1150 Joules/gram or J/g. M43, which is used in the M900A1 cartridge,
10 has an impetus of 1181 J/g. Both of these conventional propellants do not have the energy level to deliver the muzzle velocity required in future high energy tank systems such as the M829E3. Theoretical calculations have shown that a propellant containing an energy above the 1300 J/g threshold is needed.

15 In addition to the energy content, it has been shown by theoretical calculations that the ballistic cycle can be optimized and work output can be maximized by using a combination of two equienergetic propellants whose burning rates are different by a factor of three or four. The slow burning propellant is designed to
20 enter the cycle at a later time. Current standard propellants do not exhibit such wide variation in burning rates at a specified energy level. Standard tank gun propellants such as XM39, M43, M44 or JA2 have burning rate differentials that are, at best, less than two to
25 one, and thus they are unsatisfactory for solving the problem of delivering much higher muzzle velocities.

In addition to the inability to generate adequate energy levels, present day propellants produce volatile organic compounds and
30 ancillary waste, especially in enhanced demil and recyclability.

Accordingly, one object of the present invention is to provide a pair of high energy propellants whose average impetus is at or above the
35 1300 J/g level.

Another object of this invention is to provide a pair of high energy propellants whose burning rate differential is three or greater.

An additional object of this invention is to provide new energetic materials and processes that eliminate or greatly reduce both volatile organic compound production and ancillary waste through
5 demil and recyclability.

Other objects will appear hereinafter.

SUMMARY OF THE INVENTION

5 It has now been discovered that the above and other objects of the present invention may be accomplished in the following manner. Specifically, it has now been discovered that an improved high energy propellant may be prepared that has an impetus value of at least 1300 J/g. This family of propellants is expected to be of great value in new versions of the M829 cartridge as well as for other
10 future tank systems yet to be developed.

The propellant comprises an oxetane thermoplastic elastomer energetic binder admixed with a high energy explosive filler. An oxetane thermoplastic elastomer can be melted at moderate
15 elevated temperature and then solidified into an elastomeric material once it is cooled to a lower temperature such as ambient or lower. It is made from two types of monomers: 3,3-bis-azidomethyl-oxetane, or BAMO as a hard block, and 3-azidomethyl-3-methyloxetane, or AMMO as a soft block. The oxetane thermoplastic
20 elastomer energetic binder, or AMMO/BAMO, eliminates the need for solvents in processing. It is included as a binder in an amount suitable for processing and formulating the desired propellant. Preferred amounts range from about five percent to about thirty percent by weight, based on the total weight of the propellant.

25 The high energy explosive filler comprises from about seventy percent to about ninety-five percent by weight of the propellant. There are a number of preferred propellant fillers. is selected from the group consisting of Hexanitrohexaazaisowurtzitane or CL-20, 1,3,3-Trinitroazetidine or TNAZ, and the presently used RDX.
30 Mixtures thereof are also contemplated, particularly in paired propellants as described below.

35 The preferred propellant of this invention may also include an explosive plasticizer, preferably in an amount of about four percent to about seven percent of the plasticizer by weight of the propellant. Examples of preferred plasticizers are 1,3,3-Trinitroazetidine or

TNAZ, Butane-trio-trinitrate or BTTN, Trimethylolethane Trinitrate or TMETN, Triethylene Glycol Dinitrate or TEGDN, Bis, 2,2 - Dinitro propyl acetal/Bis 2,2 - Dinitro propyl formal or BDNPA/F, Methyl Nitrate ethyl nitramine or methyl NENA, ethyl NENA. These plasticizers may be used alone or in combination.

It has also been discovered that a pair of high energy propellants may be combined to produce a propellant mixture having a first propellant having a burning rate at least three times faster than the burning rate of the second propellant. In the preferred embodiment, the first propellant includes an oxetane thermoplastic elastomer energetic binder admixed with CL-20 high energy explosive filler. The second propellant including an oxetane thermoplastic elastomer energetic binder admixed with RDX high energy explosive filler or RDX and TNAZ mixtures. The ratio of burning rates may be varied from at least 2.0 times to as high as 4.8 times, or higher. Of course, plasticizers and relative amounts for each of the first and second propellants are within the same ranges as for the single propellants.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention has many advantages over the prior art propellant formulations. In its simplest form, the invention comprises an oxetane thermoplastic elastomer energetic binder admixed with a high energy explosive filler. A plasticizer may be added in some applications.

The oxetane thermoplastic elastomer energetic binder is an essential part of the invention, and is available from Thiokol Corporation. It is capable of being melted at elevated temperatures to allow the binder to be processable with other propellant ingredients without the use of solvents, and this is a major advantage. In addition, as will be shown below, the oxetane thermoplastic elastomer energetic binder has excellent mechanical properties that are superior to conventional propellants because of elastomeric characteristics, especially at cold temperatures such as -20° to -40° F. This binder also has good mechanical properties that are important for uniform ballistic performance as well as having low vulnerability to shaped charge jet impact.

In order to verify the excellent properties of the oxetane thermoplastic elastomer energetic binder, thermal stability tests were performed. Results of these tests are shown in Table I below.

TABLE I

<u>Sample</u>	<u>Self Heat, °C</u>	<u>Ignition, °C</u>
OXETANE Only	166	229
OXETANE/TNAZ (1:1)	153	216
OXETANE/CL-20 (1:1)	181	206
OXETANE/RDX (1:1)	196	222

In order to demonstrate the effectiveness of the propellants of this invention, a number of gun propellant formulations were mixed and extruded. The method of preparing the formulations comprised the

steps of mixing at about 95 °C and extruding at slightly lower temperatures. Processing at these temperatures provided a safe operating margin of at least 50 °C because the self heat temperatures of the filler ranges from about 175 °C to 192 °C, but the preferred plasticizer TNAZ melts around 100 °C, so that as some of the TNAZ begins to melt during processing at 95 °C, a more fluid mix results that is easier to process. Presented below in Table II are seven formulations that have been prepared. All values for the composition are given in percent by weight, based on the total weight.

TABLE II

	Sample	Oxetane	Filler/amount	Impetus, J/g	Flame, °K
15	A	24	CL-20/76	1297	3412
	B	24	TNAZ/76	1309	3321
	C	20	TNAZ/76*	1335	3475
	D	20	CL-20/76*	1324	3575
	E	13.3	RDX/80**	1319	3395
20	F	18	RDX/76***	1306	1348
	G	20	CL-20****	1348	3683

* Sample also included 4 % BDNPA/F as plasticizer

** Sample also included 6.7 % BDNPA/F as plasticizer

*** Sample also included 6 % TNAZ as plasticizer

25 **** Sample also included 4% TNAZ as plasticizer.

Each of the above batches was formulated into a propellant by mixing and then extruding at a lower temperature. Selection and control of the precise extrusion parameters was important to obtain proper grain dimensions without excessive swelling or deformation. Table III below identifies the barrel temperature, die temperature and ram speed for each sample batch.

TABLE III

	<u>Sample</u>	<u>Barrel temp., °C</u>	<u>Die temp., °C</u>	<u>Ram speed, in/min.</u>
5	A	82	70	0.14
	B	95	86	0.14
	C	89	82	0.06
	D	87	78	0.03
	E	100	91	0.14
	F	100	85	0.08
10	G	66	55	0.04

Each of these formulations were tested for various properties to demonstrate the efficacy of the present invention. Specifically, impact, differential thermal analysis (DTA), and electrostatic and friction sensitivity characteristics. Presented below in Table IV are the results of these tests. The results show that impact sensitivities are similar to the conventional propellant M43, and that the products of this invention are quite thermally stable. A negative annotation for electrostatic sensitivity indicates no reaction to a 12 Joule electrostatic charge while a negative friction value is for a test with a 60 pound weight. The last two samples were not fully tested and n/a indicates that no data is available.

TABLE V

	<u>Sample</u>	<u>Impact</u>	<u>DTE, Self heat</u>	<u>DTA, Ignition</u>	<u>Electrostatic</u>	<u>Friction</u>
		(cm)	(°C)	(°C)	(12 Joules)	(Bole)
30	A	50	179	203	neg	neg
	B	40	175	211	neg	neg
	C	20	175	212	neg	neg
	D	40	174	206	neg	neg
	E	40	206	225	neg	neg
	F	n/a	n/a	n/a	neg	neg
	G	n/a	n/a	n/a	neg	neg

The next evaluation of these samples was to determine the burn rate at various conditions. The data for the burn rates, presented

below in Table VI, represent closed bomb data. As can be seen, RDX containing samples E and F have the slowest burning rates, which is comparable to the LOVA type M43 formulations. The CL-20 samples A, D and G have much faster burn rates, the improvement being about 2.7 times at 10,000 psi and 4.8 at 25,000 psi. The TNAZ filled samples B and C have intermediate burning rates and sample G is the fastest. Based upon this data, a combination of a first propellant having burning ratios at least three times faster than a second combined propellant is now possible.

TABLE VI

	Sample	10 kpsi	15 kpsi	25 kpsi	Exponent	Friction
		(inch/sec)	(inch/sec)	(inch/sec)		(10 ⁻³)
15	A	4.5	6.9	11.8	1.04	0.30
	B	3.1	4.7	7.9	1.02	0.25
	C	3.5	5.1	8.4	0.97	0.46
	D	4.5	6.8	11.2	0.98	0.54
	E	1.7	2.6	4.4	1.03	0.14
20	F	1.7	2.7	4.5	1.04	0.12
	G	4.6	9.0	21.0	1.65	0.001

To complete the evaluation of the samples, some mechanical behavior tests were performed, the results of which are below in Table VII. Tests were done on an Instron test machine at low strain.

TABLE VII

	Sample	Stress,	% elong	Modulus,	Fail Modulus,	Failure Mode
		(psi)	(@ max stress)	(psi)	(psi)	
30	A	1780	36.7	7650	742	B
	B	1260	26.2	8370	2480	B
	C	412	22.8	3160	1280	B,P
35	D	641	30.4	3190	456	B,P
	E	555	16.5	6220	2870	P,SC
	F	1970	18.8	18,800	5760	P,S
	G	1680	30.8	8860	2860	P

The symbols for the failure data in the last column of Table VII are as follows: B = barrel, P = pancake, SC = slight crumble, and S = split

- 5 The data shows that high energy gun propellants at an energy level of 1300 J/g can be formulated with an Oxetane binder in combination with high energy fillers. Desirable burning rates with burn rate differential by a factor of 3 or more can be obtained from these formulations.

10

While particular embodiments of the present invention have been illustrated and described herein, it is not intended that these illustrations and descriptions limit the invention. Changes and modifications may be made herein without departing from the scope and spirit of the following claims.

15

WE CLAIM:

1. A propellant mixture formed by combining a pair of high energy propellants, said pair having a first fast burn rate high energy propellant and a second slow burn rate high energy propellant, the ratio of the fast burn rate to the rate of the slow burn rate being at least three as measured at 25 kpsi, the pair of propellants being equi-energetic and having an average impetus of at least 1300 Joules/g, the first propellant having 20% by wt. of an oxetane, thermoplastic elastomer energetic binder, 76% by wt. Cl-20 and 4% by wt. of TNAZ, the second propellant including an oxetane thermoplastic elastomer energetic binder and RDX, whereby the second slow burn rate propellant enters the ballistic cycle later than the first fast burn rate propellant
2. The propellant mixture of claim 1 where the fast burn rate is 21.0 inches /sec as measured at 25 kpsi.
3. The propellant mixture of claim 1 where the slow burn rate is 4.4 inches/ sec as measured at 25 kpsi.
4. The propellant mixture of claim 1 where the slow burn rate is 4.5 in. /sec as measured at 25 kpsi.
- 5.. The propellant mixture of claim 1 where the ratio of the fast burn rate to the slow burn rate is up to 4.8/1 as measured at 25 kpsi.

ABSTRACT

A high energy propellant, comprising an oxetane thermoplastic elastomer energetic binder admixed with a high energy explosive filler. The oxetane thermoplastic elastomer energetic binder preferably comprises from about five percent to about thirty percent by weight and the high energy explosive filler comprises from about seventy percent to about ninety-five percent by weight of the composition. A preferred propellant further includes an explosive plasticizer, preferably in an amount of about four percent to about seven percent of the plasticizer by weight of the propellant. The preferred filler is selected from the group consisting of CL-20, TNAZ, RDX and mixtures thereof. The preferred plasticizer is selected from the group consisting of TNAZ, BTTN, TMETN, TEGDN, BDNPA/F, methyl NENA, ethyl NENA and mixtures thereof. In a preferred embodiment, the propellant is actually a pair of high energy propellants comprising a mixture of first and second high energy propellants with the first propellant having a burning rate at least two times faster than the burning rate of the second propellant. The first propellant includes an oxetane thermoplastic elastomer energetic binder admixed with CL-20 high energy explosive filler. The second propellant including an oxetane thermoplastic elastomer energetic binder admixed with RDX high energy explosive filler. Plasticizers and relative amounts for each of the first and second propellants are the same as for the single propellant.

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)	Attorney Docket Number	DAR-18-95A1
	First Named Inventor	Thelma Manning
	<i>COMPLETE IF KNOWN</i>	
	Application Number	/
	Filing Date	
	Group Art Unit	
<input type="checkbox"/> Declaration Submitted with Initial Filing	OR	<input type="checkbox"/> Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)
Examiner Name		

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

HIGH ENERGY THERMOPLASTIC ELASTOMER PROPELLANT

the specification of which

(Title of the Invention)

☒ is attached hereto
OR

☐ was filed on (MM/DD/YYYY)

as United States Application Number or PCT International

Application Number

and was amended on (MM/DD/YYYY)

(if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached?	
				YES	NO
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	<input type="checkbox"/> Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.
60/006,671	11/13/1995	

[Page 1 of 2] 4

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U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)
08/744,042	11/06/1996	
09/038,490	03/06/1998	

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☐ A petition has been filed for this unsigned inventor

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